The Access Grid as Knowledge Technology

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I think, therefore I am. — *Descartes*

Since WACE 2004 is being held in France, We have chosen to begin our discussion of the Access Grid (AG) by quoting this famous maxim from one of the best-known French philosophers and mathematicians. Many of you may immediately think that this maxim is perhaps more appropriate for a workshop on, say, artificial intelligence (AI) instead of advanced collaborative environments. Yes, on the surface, the AG does not "think" by itself as an intelligent agent or an expert (knowledge-based) system would pretend to do. However, thinking is really not something we can ask a machine to do at this time—hence, the importance of human agency in any human-computer system. That is exactly what distinguishes the Access Grid from AI: the Access Grid is a *human-centered technology*. Instead of replacing human intelligence, as AI tends to do, the Access Grid augments it. Since intelligence is usually defined as "the capacity to acquire and apply knowledge,"[1] we come to our first affiliation between the Access Grid and knowledge. Furthermore, the Cartesian maxim is actually about epistemology or theory of knowledge, which, although it has something to do with AI, should be more relevant to what we are talking about today—collaborative environments—for reasons given below.

It is a bit ironic that we still travel from all around the world to meet for a topic that is supposed to set us free from such constraints. This situation brings us to an issue this paper will try to resolve: how to measure the success of collaborative environments? For the Access Grid, for example, we have more and more nodes available all around the world. Does that fact indicate that we have a critical mass of users? This is an important question. A collaborative environment differs from other technologies in that the benefits for its early adopters are less than those for its later adopters because of the interdependence between early and later adopters. If a critical mass of users is not established within a certain time frame, early adopters may stop using the technology as the number of other users one can collaborate with through that technology is limited. How many users or nodes count as a critical mass? No benchmark numbers exist, as far as we know. As a matter of fact, this is a question probably not to be answered quantitatively, even though the majority of researchers in this field prefer numbers. Instead, we offer a "dummy variable" approach here to evaluate the critical mass problem, which, in turn, will bring up the main concern of this paper.

We all agree that the Access Grid is a collaboration technology; that is, from the perspective of process, it enables AG users to collaborate with each other. From the

[1] *The American Heritage® Dictionary of the English Language*, fourth edition.

perspective of content, however, we do not yet have a shared understanding of what the Access Grid primarily deals with. Since the AG is based on network technology, we may use the following example to explain this problem. Network technology as process is about networking; as content, it is about information. That is why it is also called "information technology" (IT) in addition to "network technology." Usually, technologists call it "network technology" while users who are not technically oriented prefer to call it "information technology." This is a good example of how identifying a technology from the perspective of content instead of process may indicate its progress in user acceptance of that technology. As network technology has grown into an indispensable part of the everyday work of more and more users, IT has become a more popular name. It seems that while developers care for the process or the "how-problem" (how to implement it?) of a technology, users hold dear the content or the "what-problem" (what it can do for me?) of that technology. When attention to the "what-problem" matches or exceeds attention to the "how-problem" of a technology, that technology can be considered a mature technology, with a critical mass of users established. For the Access Grid, the "how-problem" still dominates its current research and development, for example, how to enhance the sense of presence and resolve the eye-contact problem. In other words, the Access Grid is still a technology that fits McLuhan's aphorism "The medium is the message" quite well.[2] To gear up for the development of the next-generation AG, we need to promote an increased awareness of its content, which implies an established critical mass of users who care what this technology can do for them.

Collaboration is a complicated activity. Although the purpose of collaboration is usually the creation of knowledge, considerable attention in collaboration studies is paid to issues such as technology implementation and process coordination, as any typical title of collaboration research may tell us, for example, *"Implementing Collaboration Technologies in Industry: Case Examples and Lessons Learned"*[3] and *"Coordination Theory and Collaboration Technology."*[4] Although those are worthy topics for collaboration research, they are not about the ultimate activity, or the content, that we are interested in: knowledge creation. As Suchman once said, "Every human tool relies upon, and reifies, some underlying conception of the activity that it is designed to support. As a consequence, one way to view the artifact is as a test on the limits of the underlying conception."[5] To make better design of collaborative environments, we need to examine the underlying conception of knowledge creation.

Many definitions of knowledge exist. For simplicity here, we still use IT and information as our starting point. The primary difference between information and knowledge, from a perspective familiar to computer scientists, is the following: information is codifiable, while knowledge is both codifiable and noncodifiable. In other words, information is explicit, while knowledge is both explicit and tacit, with tacit knowledge often

[2] Marshall McLuhan. *Understanding Media: The Extension of Man*. McGraw-Hill Book Company, 1964.
[3] Edited by B. E. Munkvold. Springer, 2003.
[4] Edited by Gary M. Olson et al. Lawrence Erlbaum Associates, 2001.
[5] Lucy Suchman. *Plans and Situated Actions: The Problem of Human-Machine Communication*. Cambridge University Press, 1967.

dominating our conception of knowledge. This difference is reflected in our everyday language. For example, we often ask, "Where is that information?" but usually not "Where is that knowledge?" Instead, we ask, "Who knows that?" In other words, information is independent, while knowledge usually entails a human knower. Information resides in media and networks, while knowledge resides in human agency. Both AI and IT deal with information and codifiable knowledge only. To AI, everything is conceivable and codifiable for a knowing machine. That is, of course, largely an exaggeration and one of the reasons why AI has failed. To IT, everything codifiable is also communicable. The problem is that certain knowledge exists that is not codifiable and, hence, not easily communicable through any medium other than face-to-face communication, for example, tacit knowledge embedded in certain experts and specific contexts. Here is where the Access Grid fits in—it can enable the communication of tacit knowledge directly between human knowledge holders over distance. Instead of codifying every bit of knowledge into expert systems or intelligent agents and letting those systems or agents run the world, as AI researchers would like to do, or codifying only codifiable knowledge and leaving the uncodifiable alone, as network technologists prefer to do, AG developers try to build a collaborative environment with rich audio and video capacities to support human knowledge holders to communicate directly with each other in a way as close to face-to-face communication as possible. Although information and some explicit knowledge can be encoded into a machine, the Access Grid is not used to search for such information and knowledge. Instead, people use the AG mainly to share expertise or knowledge not available from either AI or IT: knowledge embedded in human agency. In fact, the AG (except for the Access Grid Documentation Project) has minimum information and explicit knowledge built-in but maximum possibility to share and create knowledge. Thus, the AG necessitates human agency and has to incorporate human factors into its design process.

Since knowledge is what the Access Grid deals with, it should be called a *knowledge technology* (KT) from the perspective of content, just as it is also called a collaboration technology from the perspective of process. As our society switches from an information society to a knowledge society and as collaboration technologies become more and more important, identifying the AG as a knowledge technology would, in theory, promote it as the next leading technology in computer science after IT. In practice, it would guide us to design the AG as a platform for collaborative knowledge creation. As mentioned before, there are two types of knowledge: explicit and tacit. These two types of knowledge are complementary, and their conversion provides an opportunity for knowledge creation. According to Nonaka and Takeuchi,[6] two of the best-known knowledge specialists, there are four modes of conversion between explicit and tacit knowledge: (1) *socialization* (from tacit to tacit knowledge), (2) *externalization* (from tacit to explicit knowledge), (3) *combination* (from explicit to explicit knowledge), and (4) *internalization* (from explicit to tacit knowledge). The most important aspects of those conversions are proximity (space) and interaction (agency), both of which are just what the Access Grid is all about.

[6] I. Nonaka and H. Takeuchi. *The Knowledge-Creating Company: How Japanese Companies Create the Dynamics of Innovation*. Oxford University Press, 1995.

In a later study, Nonaka, Konno, and Toyama[7] further suggest that a shared space is the foundation of knowledge creation.

According to this shared space conception, four types of space support each mode of knowledge conversion. The first is *originating space*, where individuals share feelings, emotions, experiences, and mental modes. In the AG, certain virtual venues, such as lobbies, test rooms, and institution rooms, may be considered as originating spaces. To use an epistemological metaphor, the guiding principle here is "I test; therefore I am." This space is associated with the *socialization* process that supports tacit knowledge to tacit knowledge conversion. The second type of space is *dialoguing space*, where the right people and specific knowledge for a collaborative project team are mixed. Through dialogue, individuals' mental modes and skills are converted into common terms and concepts. Tacit knowledge is made explicit here. It corresponds to the *externalization* process. The guiding principle here is "I talk; therefore I am" plus Cartesian logic. In the AG, many institution rooms and some shared venues are such spaces. Peer-to-peer interaction dominates in such spaces. The third type of space is *systematizing space*, where new explicit knowledge is combined with existing knowledge to generate results of collaboration. It matches the *combination* process. Here tools such as information visualization, shared browsers, storage, and databases are available, and Cartesian logic dominates. This is the core space of collaboration and knowledge creation. In the AG, many venues with tools available may be considered as such spaces. The fourth type of space is *exercising space*, where new explicit knowledge is converted to tacit knowledge, a process consistent with the *internalization* process. Interaction here focuses on training with senior mentors, colleagues, and students. The guiding principle here is "I share; therefore I am." Many AG venues that are periodically used as seminars and classrooms as well as many institution rooms are such spaces.

Of course, AG virtual venues originally were not designed as those four types of space to support those four modes of knowledge conversion. Many AG venues are basically just an empty virtual space without any specific functions built-in. They were created either as another meeting space or simply for people to park their nodes there. We are quite sure that theory of knowledge creation and knowledge space should help us improve the AG, not only theoretically, but also practically. For AG virtual venues, we believe they can be modeled as knowledge space, although they may have to evolve gradually to reach those goals and meet AG user requirements for knowledge creation. Here we would like to discuss another feature that the Access Grid may consider in its future development as a knowledge technology.

The Access Grid is a technology that truly connects people over distance and time. This fact itself is a knowledge asset that other technologies can hardly match right now. The problem is how to capitalize on this asset. Many people who come to the AG for the first time like to ask, "Who else is out there?" Usually, an AG node operator might show them

[7] I. Nonaka, N. Konno, and R. Toyama. "*Emergence of 'Ba': A Conceptual Framework for the Continuous and Self-transcending Process of Knowledge Creation*" in *Knowledge Emergence: Social, Technical, and Evolutionary Dimensions of Knowledge Creation*, edited by I. Nonaka and T. Nishiguchi. Oxford University Press, 2001.

the lobby where many nodes can be found. Many institution names are shown over those video frames from each node, which would be enough for lukewarm curiosity. For more interested visitors, we could bring up a list of AG nodes all around the world with contact information of each node. For more serious visitors who are looking for someone to help them out in their research projects, we would have to summon all we know about who is using which AG node for what projects. Many AG node operators usually have a good knowledge about other nodes, but their knowledge is more about node operators than about users at those sites. This practical knowledge comes from extensive tests and demos among AG nodes and can be helpful for such exercises in the future to guarantee smooth operation of AG nodes.

For serious AG users, however, we need another kind of knowledge that can help us quickly locate a possible collaborator over the AG. This is often called knowledge-mapping, or expertise-locating, or knowledge of knowledge.[8] For the AG, we may first collect data on each AG node's use frequency or total hours used and numbers of users in attendance, which may come up as some kind of usage index to reveal how useful each AG node may be. Then we may collect detailed information about AG users on each site: who they are; what they do; and how their reputation ranks are—as calculated from their self-report, other users' evaluations, publication numbers, and the like. Those may come up as another index of expertise. With those two indexes, we can build a map of know-how over the AG. This should be an easy technical change to implement but a big step in making the Access Grid a genuine knowledge technology.

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[8] M. Ackerman, V. Pipek, and V. Wulf, eds., *Sharing Expertise: Beyond Knowledge Management*. MIT Press, 2003.